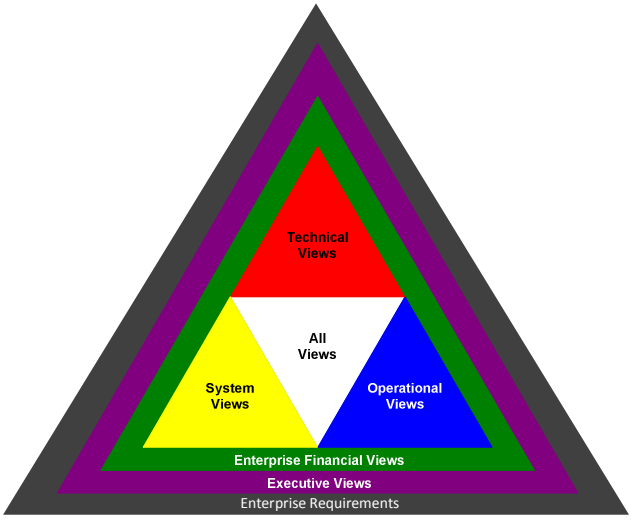
# Federal Aviation Administration

# National Airspace System Integrated Systems Engineering Framework (NAS ISEF)




## Version 3.3

**November 21, 2014**

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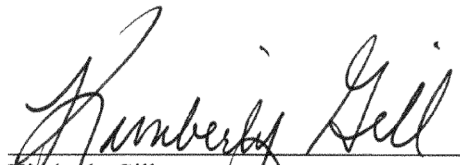

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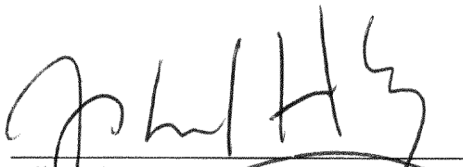

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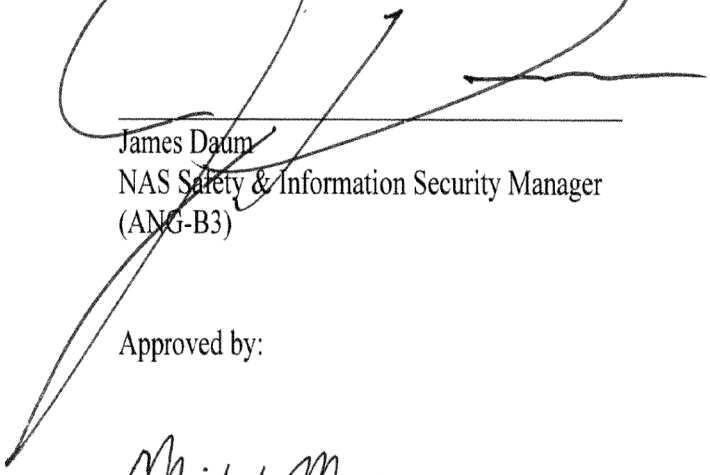

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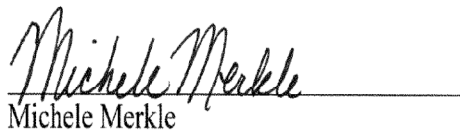

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## Version Control

| Version | Date | Author | Change Description |
|---|---|---|---|
| 1.0 | September 30, 2006 | SETA-II | Initial |
| 2.0 | September 30, 2007 | SETA-II | Introduces NAS EA Meta Model. Redefines set of hierarchical elements. Restructures product guides to emphasize NAS EA Meta Model and data-centricity. Restructures AV-1 Template. |
| 2.1 | September 30, 2008 | SETA-II | Reflects NAS EA Meta Model updates: removal of relationships between Operational Activity and Systems Function Input/Output and Systems Function to Operational Activity Input/Output. Adds new "Actor" architecture element, attributes, relationships, and rules. Adds new "source" and "sink" Systems Function Input/Output attributes and relationships. Reformulates *Rules* and updates *Sample Graphical Models* for each product development guide. Clarifies AV-1 Template treatment of alternative solutions and usage of Architecture Impact Assessment (AIA). |
| 3.0 | January 04, 2010 | SETA-II | Combines NAS EA Framework Volumes I, II, and III v2.1 into one comprehensive document. Establishes new Framework concepts for how the NAS EA fits into the rest of the ATO and the Agency. Presents a more flexible and less prescriptive set of guidelines for architecture development and analysis. |
| 3.1 | June 30, 2011 | SE-2020 | Updates title of the document to the Integrated Systems Engineering Framework to account for and describe the structure, products, and processes that apply to the development of integrated NAS architecture products and requirement documents at the enterprise-, service unit-, and program-levels. Updates corresponding figures and language, as well as the conceptual metamodel. Includes new section to describe horizontal and vertical integration concepts. Updates Appendix A, to include new product examples, development and integration guidance. Creates new Appendix B, to describe the structure, roles and responsibilities, and processes for managing and controlling the NAS architecture and requirements. |
| 3.2 | June 29, 2012 | SE-2020 | Updates include additional detail describing the development and integration of Enterprise- and Program-level architecture and requirements, edits stemming from organizational and governance changes. Other updates include the removal of references to the Service Unit-level, as well as the Data Elements tables, which are now captured in Appendix A. |

| Version | Date | Author | Change Description |
|---|---|---|---|
| 3.3 | November 21, 2014 | SE-2020 | Updates include the incorporation of the ANG-B3 perspective in the process descriptions, referencing criteria for high-priority decision points, including the Architecture Change Notice, replacing the sub-capability roadmap with the NSIP, and including additional references to the Appendices C and D. |

# Table of Contents

# 1 INTRODUCTION & BACKGROUND

The National Airspace System (NAS) Enterprise Architecture (EA) continues to mature into a comprehensive, multiyear strategic plan and framework for improving and evolving the NAS from the current portfolio of fielded Air Traffic Management (ATM) services and capabilities through 2025 and beyond. Equally important, the NAS Requirements describe what the NAS must do to provide the service and capability specifications. The NAS Integrated Systems Engineering Framework (ISEF) evolves the original NAS EA Framework v1.0 to capture the relationship between, and alignment of the NAS Requirements and NAS EA. The alignment enables traceability of Enterprise- and Program-level requirements to the operations, systems, and services that perform them today and in the future - ensuring continued consistency between the EA and Requirements as the NAS evolves. This version of the ISEF incorporates additional perspectives (i.e, safety and information security), both closely aligned to the NAS Requirements and NAS EA. Creating a stronger relationship between the four disciplines (i.e., requirements management, architecture modeling and analysis, safety and information security) strengthens the set of interrelated program planning documentation and data required by the *Federal Aviation Administration's* (FAA) *Acquisition Management System* (AMS) that collectively influence the FAA's ability to refine the vision, develop strategies and plans for achieving the vision, make resource decisions, implement strategies, and evaluate performance.

## 1.1 Purpose and Audience

The ISEF establishes a common lexicon and defines the structure for organizing and relating NAS systems engineering data and resulting documentation in a coherent, consistent manner to support planning and decision making. It is primarily intended to support the NAS systems engineering community however, it also serves as a reference to other internal and external stakeholders for communicating the data, structure, products, value, and processes that apply to the development of integrated systems engineering data and documentation at the Enterprise and Program-levels. The ISEF Appendices also provide additional guidance and instruction on creating and managing the documentation and data described herein and their value.

## 1.2 Document Structure

The document is organized as follows:

- Section 2, *Form and Structure,* provides an overview of the ISEF and the structure to hierarchically relate and organize the content contained throughout the NAS-related planning and systems engineering documentation
- Section 3*, Enterprise-level processes and practices,* describes key processes and approaches relevant to Enterprise-level systems engineering documentation and data development, updates and approval
- Section 4*, Program-level Processes and Practices,* describes key processes and approaches relevant to Program-level systems engineering documentation and data development and approval primarily in support of acquisition decisions
- Section 5, *Integrated Systems Engineering Analysis,* describes the techniques used to analyze the planning and integrated systems engineering information to enhance decision support
- Appendix A*, Products, Development, and Integration Guidance,* presents a set of reference

examples, rules, and styles for developing, integrating, and aligning architecture and requirements data
- Appendix B, *Governance,* presents the structure, roles and responsibilities, and processes for managing and controlling the NAS systems engineering documentation and data.
- Appendix C, *Metamodel*, defines the core systems engineering data entities, attributes and associations that support the form and structure of the NAS ISEF.
- Appendix D, *Configuration Management Plan,* defines the processes, roles and responsibilities for managing changes to the systems engineering documentation and data.

### 1.3 Document References

The NAS ISEF references the following documents:

- FAA Acquisition Management System (AMS)
- FAA Capital Investment Plan (CIP)
- FAA Destination 2025
- FAA Systems Engineering Manual (SEM)
- FAA NAS Segment Implementation Plan (NSIP)
- FAA Mentoring Process Guide (MDG)
- FAA Saftey Risk Management Guidance for Systems Acquisition (SRMGSA)

## 2 FORM AND STRUCTURE

The NAS ISEF, depicted in Figure 1, represents an integrated and federated framework to support the development and analysis necessary to guide the FAA towards the future vision of the NAS. It comprises an integrated set of systems engineering documentation and data that represent various perspectives of the NAS over time, in varying degrees of breadth, and detail. The ISEF provides the frame to hierarchically relate and organize the content contained throughout the NAS-related planning and systems engineering documentation maintained at the Enterprise- and Program-levels.

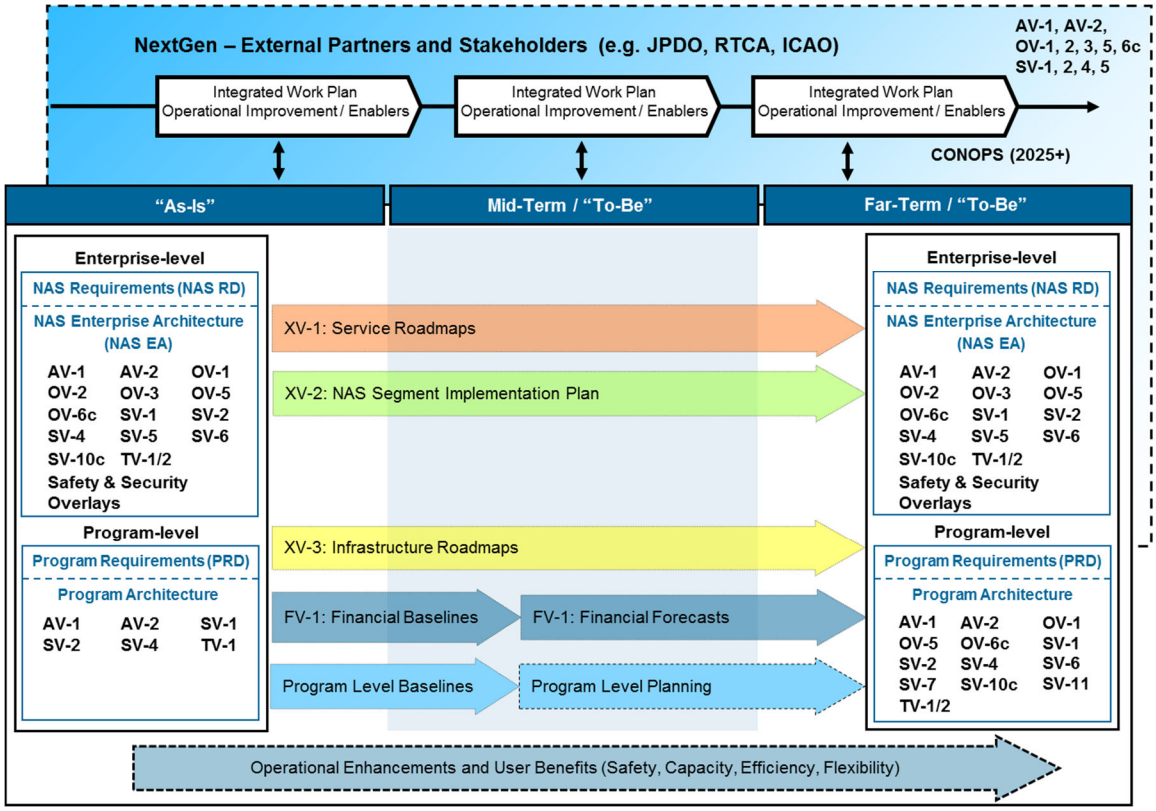



**Figure 1: National Airspace System Integrated System Engineering Framework**

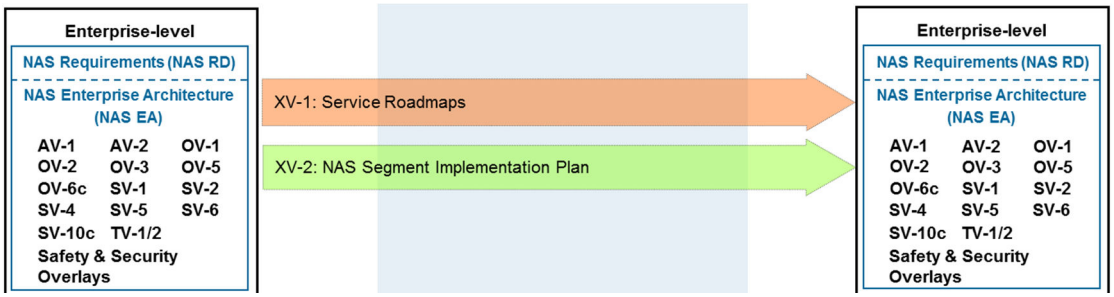
Essential to the NAS ISEF is the underlying metamodel and corresponding physical data model that supports analytical decision making and provides transparency between the NAS goals and objectives described in *FAA's Destination 2025* to the NAS Mission Services, their supporting operational and functional requirements, and the materiel and non-materiel investments (i.e. systems/services, research, development, policy) needed to achieve the full capability. The metamodel, described in Appendix C, defines each of the core data entities identified in the ISEF, as well as the relationships and required attribution associated with each. It is important to distinguish between the metamodel (conceptual and logical) and the physical model instantiated using a tool/repository. The metamodel is a blueprint that describes the kinds of data stored and connected in repositories implemented with technologies like the NAS EA Portal, or IBM's Rational System Architect and DOORS.

## 2.1 Timeframes and Levels

There are three distinct timeframes that appear in Figure 1, that is the As-Is, the Mid-Term (To-Be), and the Far-Term (To-Be), each intended to represent the NAS at a particular point in time. The As-Is depicts how the NAS exists today, while the Mid- and Far-Term To-Be states represent how the NAS should/could exist in the future. The As-Is perspective is extremely important in establishing a common basis for management and planning by providing input to gap and impact analysis and the configuration control of the NAS. The To-Be perspectives are equally important by providing a target for aligning current decisions, as well as the basis for more strategic investment/program planning and acquisition.

Within each timeframe there exists a collection of integrated architecture content and related requirement statements at different degrees of breadth and abstraction (i.e., Enterprise- and Program-level).
The following sections detail the extent of breadth and abstraction for each level of perspective.

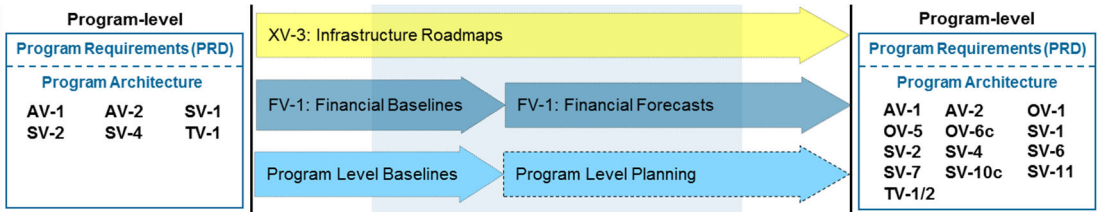
### *2.1.1 Enterprise-level*




The Enterprise-level covers the entire NAS system of systems, including the operational and functional perspective. It provides a high-level context and is the broadest in scope, and includes the NAS EA and associated NAS-level requirements. The NAS Requirement Document (NAS RD) captures the operational and functional requirements associated with the NAS Services. The functional requirements are derived from the operational requirements, and are decomposed to a level that can be allocated to specific NAS portfolios, programs, projects and/or systems. The NAS EA is a modeled interpretation of NAS operations as defined in the NAS Concept of Operations and other documentation, and provides the basis for deriving and organizing the requirements in the NAS RD, as well as providing context and scope for Program-level development and analysis.

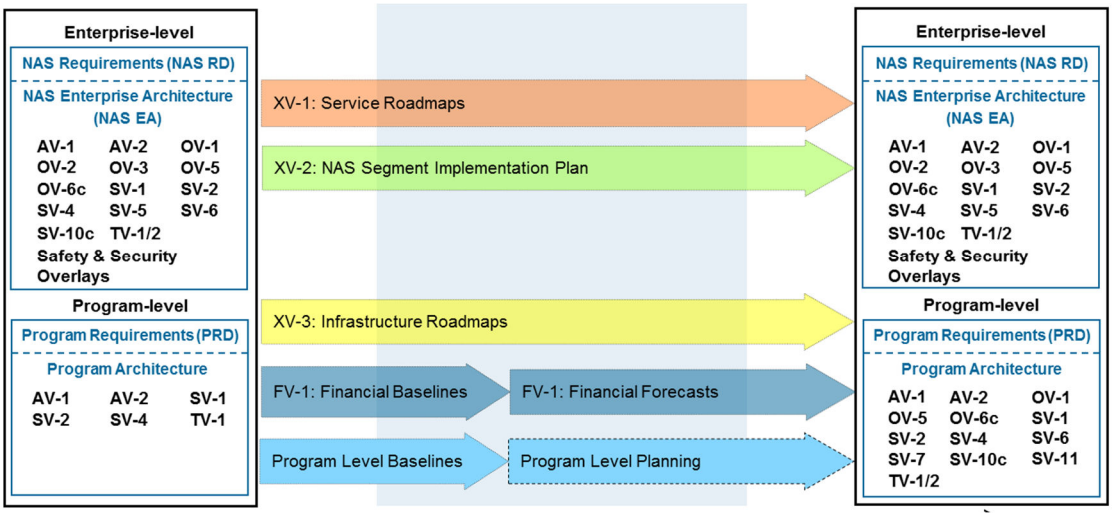
As necessary, additional Enterprise-level perspectives (e.g., portfolio, functional segment, implementation, etc.) may be created to enable supplemental contextual analyses and decision making.

### *2.1.2 Program-level*




Program-level Requirement Documents and Architectures are developed as a basis for individual system acquisition within the context of NAS Enterprise-level products. This level may be represented by a single project or system, a collection of projects (i.e., a program), or an operational or functional capability. Together the program architecture and associated requirement documents represent an integrated description of the program, project, system, service, and/or capability.

## 2.2 Architecture Content and Views




The NAS EA content and views are derived from the Department of Defense Architecture Framework v1.5 (DoDAF). The DoDAF is a tailorable architecture framework, evidenced by the selection and application of required views described below. Product form, in terms of relevant elements and attributes are tailorable as well.

The white boxes in Figure 1 list the set of views that can be extracted from the Enterprise and Program level architecture models. The list within each box does not preclude the development of other views for any particular architecture. In addition, the NAS Chief Architect may deem other views as necessary or desired to meet a specific business need (e.g., fit-for-purpose). Appendix A details the choices, adaptations, and modifications made against DoDAF for the products specified for Enterprise- and Program-level development. The colored arrows within Figure1 represent additional views of the NAS EA and are further described in the following sections.

### *2.2.1 Executive Views*

The Executive Views (XV) represent strategic planning roadmaps that depict the evolution and delivery of NAS services, capabilities, benefits, functionality, and investments over time. They are comprised of three related roadmaps: the Service Roadmap, NAS Segment Implementation Plan, and the Infrastructure Roadmap.

#### *2.2.1.1 XV-1 Service Roadmap*


The XV-1 or “NAS Service Roadmap” is a rolling multi-year strategic roadmap that depicts the expected evolution and delivery of NAS services, capabilities, and benefits over time. More specifically, it outlines the strategic activities for service and capability delivery to sustain and improve NAS operations towards the target state vision. The Current Operations (CO),

Operational Improvements[1], and Support Activities on the roadmaps are used to guide, inform, and focus deliberations on NAS capabilities. The Service Roadmaps are updated annually as research and analyses more clearly define the evolution of NAS services. The latest approved version of the NAS Service Roadmaps can be found online at https://nasea.faa.gov/products/sr/main. Figure 2 depicts a sample Service Roadmap for Initiating Trajectory-based Operations.

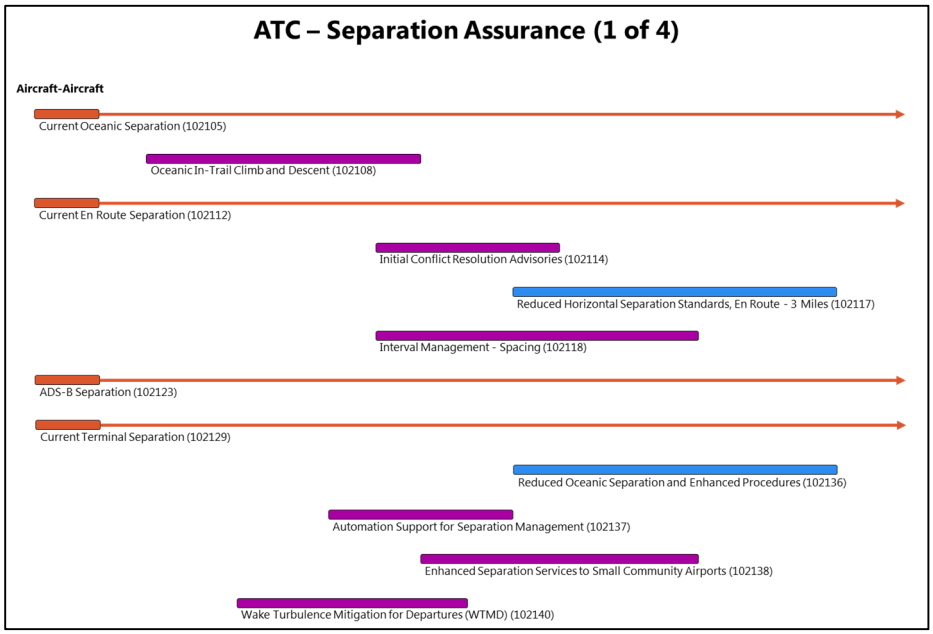
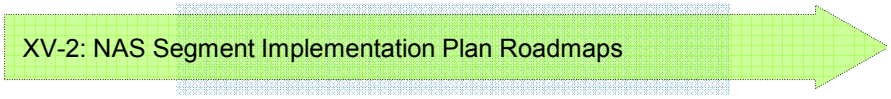



**Figure 2: Sample Service Roadmap for ATC-Separation Assurance**

Appendix A lists the XV-1 data elements and their corresponding attributes.

### *2.2.1.2 XV-2 NAS Segment Implementation Plan*




The XV-2 or "*NAS Segment Implementation Plan*" is the blueprint for achieving NextGen initiatives and sustaining specific NAS operations. It outlines the improvements and incremental delivery of expected NextGen operational changes to 2020 and beyond. The NSIP employs a portfolio approach to show dependencies and relationships of systems to capabilities. This plan also promotes scheduling coordination for implementing new capabilities. This plan is used to support the identification of integration challenges or implementing capabilities, which enables the FAA to effectively identify programmatic, technical, and operational risks in the context of achieving a portfolio's benefits. Figure 3 depicts a sample of the *NAS Segment Implementation Plan*.

[1] An Operational Improvement is a discrete strategic activity for service and/or capability delivery to improve NAS operations. They are expressed as cross-domain statements comprising sets of anticipated benefits to be realized at some future date.

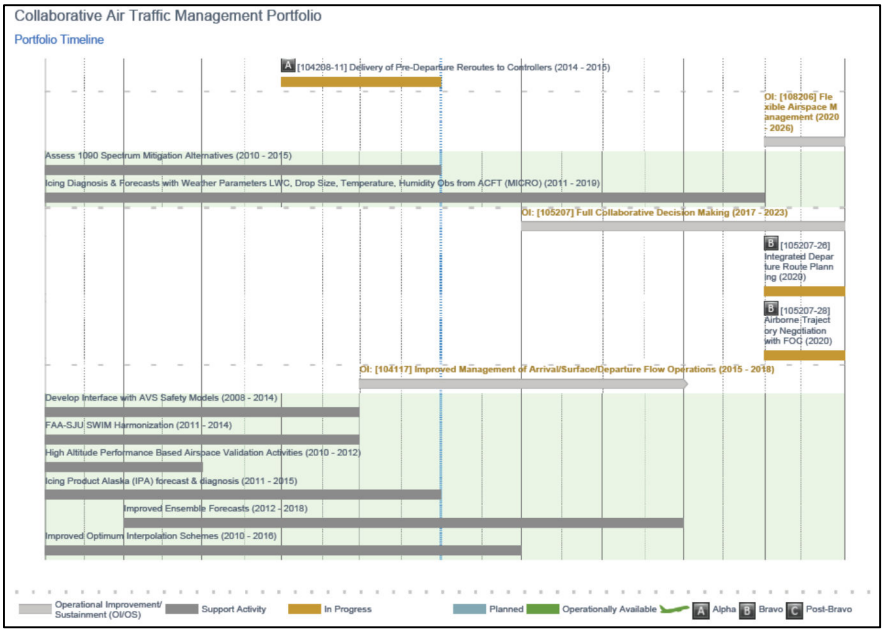



**Figure 3 Sample NSIP Timeline**

Appendix A lists the XV-2 data elements and their corresponding attributes.

### *2.2.1.3 XV-3 Infrastructure Roadmap*


The XV-3 or "NAS Infrastructure Roadmap" is also a rolling multi-year roadmap that depict the planned infrastructure improvements and sustainment initiatives, effectively showing the evolution of major FAA programs, projects, and systems in today's NAS infrastructure to meet the target state vision. The Infrastructure Roadmaps contain programmatic and schedule information that define the enabling infrastructure (i.e., actors, systems, services, facilities, and support activities) for ATM service delivery; identify system replacements, convergence and modernization; and the relationships among various infrastructure elements. The Infrastructure Roadmaps also identify key decision points that represent acquisition, strategy, and policy decisions associated with a particular program, project, or system. The decision points indicate the FAA's approval of a particular improvement/sustainment initiative; an investment decision that must precede implementation of an improvement initiative; or the research and/or analysis that must be conducted before an investment decision or solution implementation. The Roadmaps, combined with funding data, facilitate analysis of cost and schedule tradeoffs, and are used to guide, inform, and focus deliberations on the NAS infrastructure. The latest approved version of the NAS Infrastructure Roadmaps can be found online at https://nasea.faa.gov/products/ir/main. Figure 4 depicts a sample Infrastructure Roadmap for Weather Sensors.

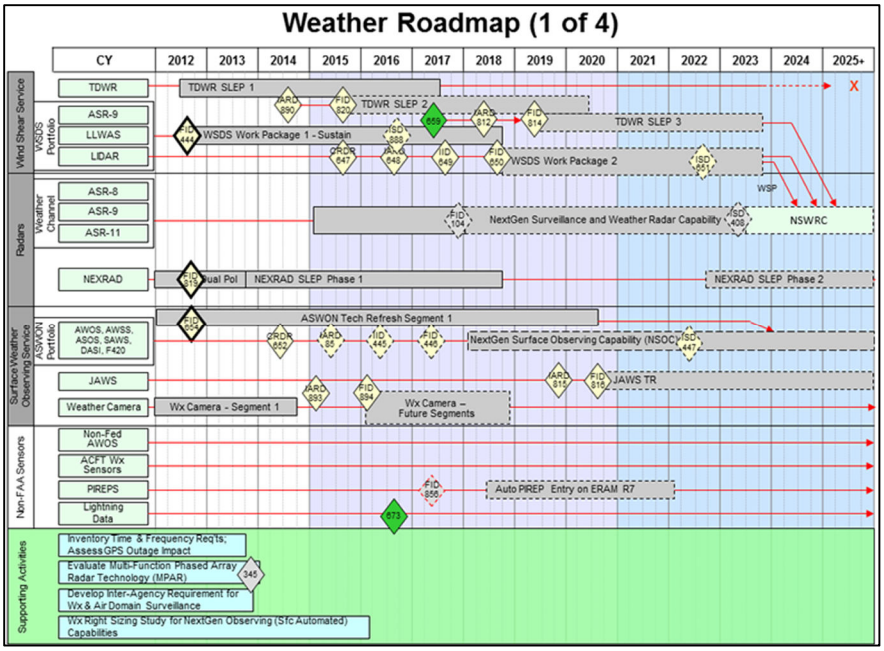



**Figure 4: Sample Infrastructure Roadmap for Weather**

Appendix A lists the NAS Infrastructure Roadmap data elements and their corresponding attributes.

### *2.2.1.4 Relationship between XVs*

As previously mentioned, the Executive View (XV) represents strategic planning roadmaps that depict the evolution and delivery of NAS services, capabilities, benefits, functionality, and investments over time. There is an inherent hierarchical relationship between the elements contained within the Service Roadmap, NAS Segment Implementation Plan, and the Infrastructure Roadmap. This relationship is depicted in Figure 5 below.

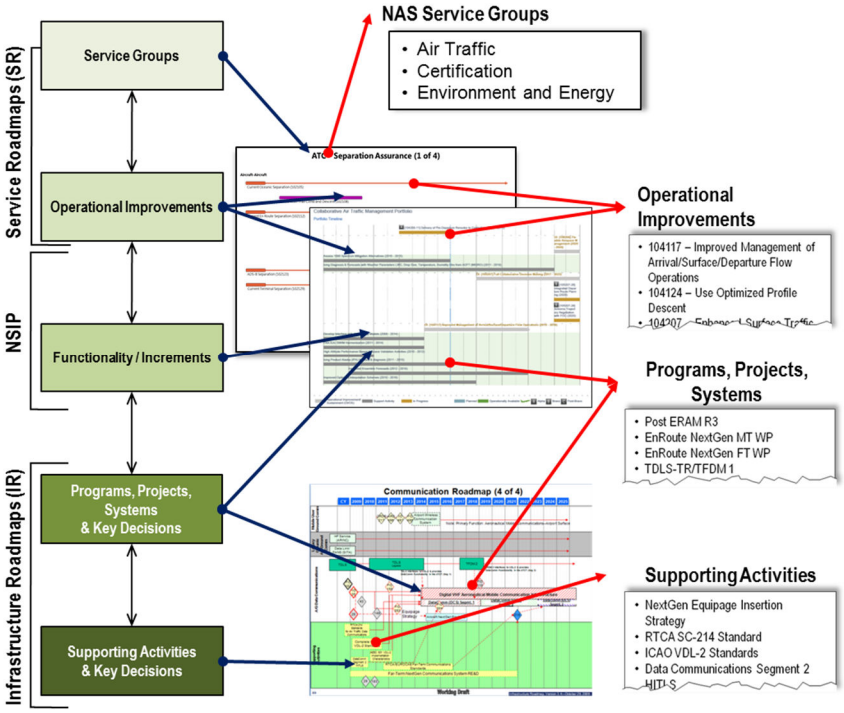



**Figure 5 Relationship between XVs**

The Service Roadmap is closely linked with the Infrastructure Roadmap through the Operational Improvements, which are organized around 3 NAS Service Groups (Air Traffic, Certification, and Environment and Energy). The Operational Improvements are further decomposed into bundled functional implementations represented as OI Increments on the NSIP Portfolio timelines. The Infrastructure Roadmaps contain programmatic and schedule relationships between infrastructure elements (i.e., systems, projects, and programs), which are also related and represented in the NAS EA system views.

### *2.2.2 Financial View*


The Financial View (FV) contains forecasted expenditures for funding initiatives (Programs and Projects) identified in the published *FAA Capital Investment Plan* (CIP) and is represented by a single product called the FV-1 or "Funding Profile." The Funding Profile depicts the Facilities and Equipment (F&E) funding for approved and forecasted NAS infrastructure programs. The Funding Profile is closely linked with the Infrastructure Roadmaps, which depicts high-level relationships between the infrastructure elements. This information combined with the Infrastructure Roadmap data enables analysis of the cost and schedule tradeoffs that exist in the budgeting and planning cycle and is used to guide, inform, and focus capital planning deliberations on the NAS infrastructure.

## 2.3 Functional Analysis Document

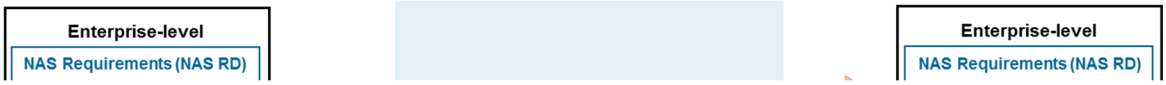
A function is a characteristic action or activity that has to be performed in order to achieve a desired system objective (or stakeholder need). A function name is stated in the form of an action verb followed by a noun or noun phrase; it is an action that describes the desired system behavior. The Functional Analysis (FA) process provides the basis for the decomposition of an oerational concept, as documented in a Solution Concept of Operations (ConOps) document, into preliminary top-level functions and data needs. FA serves as the foundation for the development of functional and performance requirements that are then documented in the Program Requirements Documents (PRD). The results of the FA process are documented in the Functional Analysis Document (FAD). It is critical that the FAD accurately represents the functions, services, inputs and outputs that are envisioned in the operational concept.

### *2.3.1 Enterprise Functional Analysis Document*

### *2.3.2 Program Functional Analysis Document*

The sponsoring program office initiates FA with the support of the NAS Requirements Services Division (ANG-B1) during the Concept and Requirements Development (CRD) phase of the AMS lifecycle. Although the bulk of the FA is conducted during the CRD phase, the FAD must be continually updated as a program matures their acquisition through the IIA and FIA phases. These can include updating the FAD to account for changes in the program's EA SV-4 or the PRD.

## 2.4 NAS Requirements Documents




### *2.4.1 Enterprise Requirements Documents*

Enterprise-level requirements are captured in a series of documents that describe the functional requirements, and associated performance requirements, for the NAS that are to be met by its systems, equipment, personnel, and procedures. The NAS Requirement Document series (NAS-RD series) exist at both the As-Is and To-Be timeframes.

The NAS-RD series describe the operational and functional requirements that are fielded or will be fielded in the NAS. It also represents the highest level system functions that are enforceable and under configuration control in the current architecture. The NAS-RD series organizes requirements per the NAS Mission Services.

The NAS-RD series is the primary means by which requirements are allocated to the Programs that are responsible for developing systems/services in support of NAS operations. The requirements are structured in a parent-child hierarchy to represent the highest levels of functional requirements to which a program can align their own requirements. The NAS-RDs also include requirements focused on mitigating safety hazards and information security risks identified during safety assessments and information security risk assessments.

Each document in the NAS-RD series represents a timeframe between the current configuration and the target state of the NAS. The requirements contained in each describe what will be

operational in the NAS during that timeframe. The NAS-RD 2025 also includes requirements associated to increments within the NSIP and provides the means to allocate these needs to programs. Additionally, each document provides a set of design principles and support requirements (RMA, communication, information security, spectrum, etc.) that represent common guidelines for programs undergoing implementation.

### *2.4.2 Program Requirements Documents*

The program requirements document drives the search for a realistic and affordable solution to mission need during investment analysis. The sponsoring line of business develops a Program Requirements Document (PRD) during concept and requirements definition, which translates the "need" in an Service and Infrastructure Roadmaps into preliminary top-level functional and performance requirements.

## 2.5 Safety Assessments

### *2.5.1 Integrated System Safety Assessments*

Integrated System Safety Assessments (ISSAs) are developed to identify safety issues across associative, dependent, and/or interacting programs/systems that may eventually be categorized as hazards. The purpose of the ISSA is to identify and assess gaps by integrating across three planes:

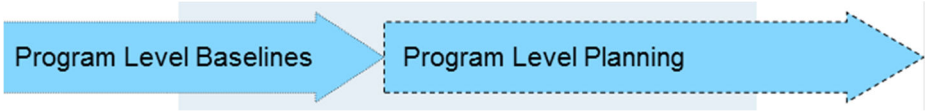
- Vertical – Hierarchical. Enterprise-level system-of-systems safety risk and requirements allocated down to programs.
- Horizontal – Across organizations, programs, systems, and functions.
- Temporal – Across program/system implementation timelines.

The identified safety issues are allocated to programs that are responsible for associated mitigations.

### *2.5.2 Program-Level Safety Assessments*

Program safety assessments drive the identification of hazards and assessment of safety risk to the program. The sponsoring line of business first develops a Safety Risk Management Document (SRMD) during concept and requirements definition, which is then updated throughout the system's lifecycle. Details on this process are contained in the SRMGSA.

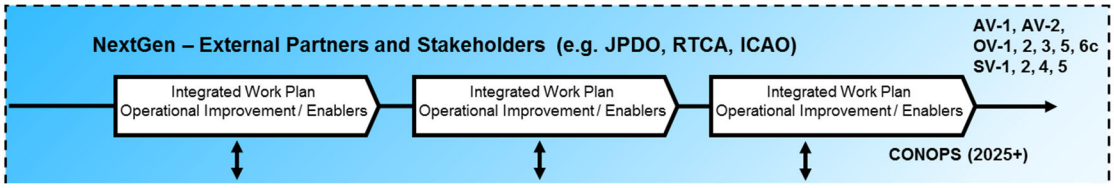
## 2.6 Program-Level Baselines and Planning




The Air Traffic Organization (ATO) Program Management Office (PMO) and the respective program offices are responsible for managing the development and evolution of individual NAS systems within their domains. A program baseline (known as Acquisition Program Baseline, APB) is established at the Final Investment Decision (FID) coincident with approval of an investment program for implementation. The APB contains critical milestones, cost, schedule, risk and performance parameters and their associated values designated for control by the investment decision authority. They relate to the FAA's commitment to satisfying the mission

need, achieving needed operational capability, and meeting schedule requirements of interdependent programs. The program-level baseline and planning data contained in the APB are currently not included in or associated with the architecture or requirements data however, plans to interface with this data in the NAS EA Portal are being considered.

## 2.7 External Partners and Stakeholders




The Joint Planning and Development Office (JPDO) is the organization that coordinates the specialized efforts of several federal government stakeholders (i.e., Departments of Transportation, Defense, Homeland Security, and Commerce, and the FAA, National Aeronautics and Space Administration, and the White House Office of Science and Technology Policy) in a public/private partnership to bring the Next Generation Air Transportation System (NextGen) to fruition. The architectural scope of this effort encompasses the broader "curb-to-curb" representation of aviation than that of the NAS' "gate-to-gate" environment, expanding into airport operations and support, FAA and non-FAA weather operations, transportation security and screening, etc. The NAS EA serves as the foundation for the broader JPDO NextGen EA and Integrated Work Plan (IWP) and therefore shares a strong alignment of architecture views and roadmap data.

## 2.8 Horizontal and Vertical Integration

The ISEF Metamodel establishes the foundation for relating systems engineering data elements at both the Enterprise- and Program-levels. The strength of the specified relationship between elements falls across a semantic spectrum, where at one end of the spectrum no relationship exists and at the other end an exact relationship exists. The concept of semantic-based relationships is further described in Table 1.

**Table 1 Semantic Relationship Types**

| Relationship Type | Description | Relationship Strength |
|---|---|---|
| **Is Equivalent to** | An element is considered "equivalent to" another element if the titles and descriptions of both are identical. (i.e., Same Scope, Same Content) | **Strongest** |
| **Is Similar to** | An element is considered "similar to" another element if the descriptions are the same but differ in scope. (i.e., Different Scope, Same Content) | **Next Strongest** |
| **Is Part of** | An element is considered "part of" another element if the description of the element achieves part of the related element scope. (i.e., Different but similar Scope and/or Different but similar Content) | **Relatively Weak** |
| **No Relationship** | An element has no relationship to any other element. (i.e., No relationship can be established due to a gap or the element falls outside of scope.) | **None** |

Ideally, integration establishes and enforces horizontal and vertical relationships and inter-dependencies between systems engineering terms and definitions to ensure consistency and

transparency across the Enterprise. The following sections describe the horizontal and vertical integration concepts in more detail.

### *2.8.1 Horizontal Integration*

Horizontal integration indicates the terms and definitions are uniquely identified and consistently used across all products and views within a singular perspective (i.e., the combination of timeframe and level). Horizontal integration occurs at both the Enterprise- and Program-levels.

It supports the identification of potential redundancies and opportunities for integration and convergence across interrelated architectures and requirements.

The concept of horizontal integration as it relates to DoDAF-related architecture views is depicted in **Error! Reference source not found.**6, where like elements are uniquely represented across the various applicable views. For example, the nodes identified in the Operational Node Connectivity Description (OV-2) are the same as those represented in the Operational Event-Trace Description (OV-6c).

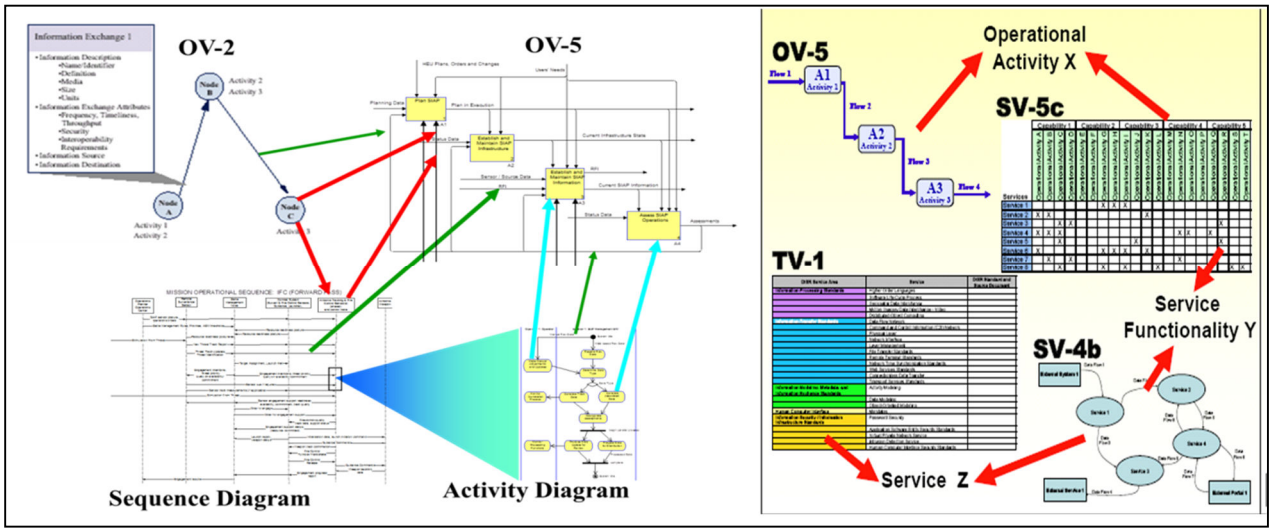



**Figure 6 Horizontal Integration of Architectural Views and Data**

The concept of horizontal integration is also applied for requirements. Each requirement in the NAS-RD is aligned to only one of the NAS EA Mission Services. Requirements spanning multiple NAS EA Mission Services are represented within the Support Requirements or Design Principles section of the NAS-RD. Horizontal integration of requirements at the Program-level ensures that requirement statements are unique within and across other Program Requirement Documents (PRD) in order to eliminate duplication of investment. In addition, the Program-level requirements are aligned to the applicable Program-level architecture views (e.g., SV-1, 4, and 6), strengthening the relationship between architecture content and requirement statements.

### *2.8.2 Vertical Integration*

Vertical integration results when data elements at the Program-level are traceable or related to data elements at Enterprise-level, and vice versa. The concept of vertical integration is depicted in Figure 7.

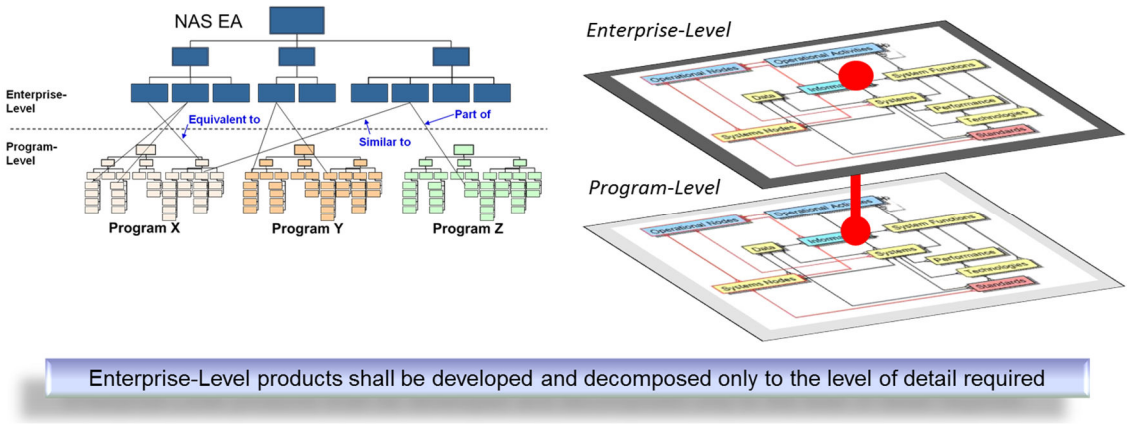



**Figure 7: Vertical Integration**

Vertical integration is dependent on a parent/child hierarchical relationship, where the "child" elements represent a decomposition of the "parent". A child element may serve as a parent when it is decomposed into even more concrete, less abstract child elements. This pattern continues to the point where further decomposition is beyond the scope and intent of the architecture. More specifically, vertical integration ensures that a Program-level architecture and requirements accommodate a top-down/bottom-up alignment with architecture elements and NAS Requirements defined at the Enterprise-level; supports its "parent" in providing NextGen benefits; aligns with NextGen Operational Improvements, addressing corresponding shortfalls; and facilitates prioritization analysis. Per Figure 7, constituent Program-level architecture elements are expected to be vertically integrated with Enterprise-level elements.

The concept of integration (i.e., horizontal and vertical) is implemented in the NAS ISEF through the following Enterprise- and Program-level processes and practices described in the following sections. Appendix A also outlines product specific development and integration guidance.

# 3 ENTERPRISE-LEVEL PROCESSES AND PRACTICES

## 3.1 NAS Enterprise Architecture Development and Maintenance

### *3.1.1 Service Roadmap Development & Update*

The NAS Service Roadmaps are updated annually in response to changes made to existing NAS Operational Improvements (OI) or the creation of new OIs. The NAS Systems Engineering Services Office (ANG-B) receives coordinated and approved updates from the Office of the Chief Scientist, Advanced Concepts and Technology Development Office (ANG-C) and NAS Lifecycle Integration Office (ANG-D), including changes to titles, descriptions, and initial operating capability date ranges. The output of this process is the updated Service Roadmaps, which are typically completed prior to or parallel to the annual update of the NAS Segment Implementation Plan and Infrastructure Roadmaps.

### *3.1.2 NAS Segment Implementation Plan Development & Update*

The NSIP is updated annually in conjunction with the Service and Infrastructure Roadmaps

during the NAS EA Product update cycle in coordination with the NAS Systems Engineering Services Office (ANG-B), Advanced Concepts and Technology Development Office (ANG-C), NAS Lifecycle Integration Office (ANG-D), and the Office of the NextGen Chief Scientist.

**Analysis and Planning Phase.** This phase begins immediately after the establishment of an approved baseline. This process consists of gathering any new requirements or deferred information. An Operational shortfall analysis is also conducted during this phase to identify any capabilities listed within the Concept of Operations that is not currently represented in the NAS EA or NSIP. The outcome of this activity is then transferred to the Development and Update Phase for further definition.

**Development and Update Phase**. The NSIP development and update process coincides with the update for the Infrastructure Roadmaps and follows the NAS ISEF, Appendix D: Configuration Management Plan processes. In this Phase, each Portfolio Manager collaborates with their perspective Stakeholders regarding any operational changes or funding impacts and submits update recommendations during the particular roadmap update process. As discussed above, proposed changes to OIs are evaluated and approved during the Service Roadmap update. In conjunction with the ANG-B led Infrastructure Roadmap process described below, the ANG-C and ANG-D organizations review and approve changes to the Increments, their timelines, and key systems and projects associations. Additionally, a final review is conducted at the end of the product development process, led by ANG-D, to review an Increment's benefits, external commitments, and success criteria for Portfolio consistency and accuracy.

**Review and Approval Phase**. The resulting plan is presented to the NextGen leadership for review and final approval, prior to briefing outcomes to the NextGen Management Board (NMB). At the conclusion of this phase the corresponding data in the NAS EA Portal is designated as the new NSIP baseline.

**Process Roles and Responsibilities.** Table 2 summarizes the active roles within the process and their general responsibilities.

**Table 2 Roles and Responsibilities for NSIP Development**

| Role | Responsibility |
|---|---|
| NextGen Management Board | Reviews final NSIP baseline. |
| NextGen Leadership | Provides final approval for the NSIP baseline. |
| Portfolio Manager | Coordinates with stakeholders and manages the information associated with the NextGen Portfolios. |
| Stakeholder / ATO PMO | Provides development guidance and technical expertise on specific NSIP elements and coordinates with the Portfolio Managers. |

### *3.1.3 Infrastructure Roadmap Development & Update*

To reflect the FAA's evolving system and infrastructure transition plans, the Infrastructure Roadmaps are updated annually following a three phase process: Analysis and Planning, Updating, and Review/Approval.

**Analysis and Planning Phase.** Each development cycle begins and ends with Joint Resource Council (JRC) approval of the latest Infrastructure Roadmap update. Approval effectively establishes a new baseline and initiates the next development cycle. Shortly after the establishment of a new baseline, the previous year's activities are evaluated to identify lessons learned and to determine new requirements based on direction/priorities provided by the NAS Chief Architect and NextGen executive leadership, roadmap data analysis findings and recommendations, and other applicable and accepted stakeholder requests and comments collected throughout the year. New requirements may take many forms including process improvements, additional data requirements to support reporting and analysis, the integration of additional data sources, etc.

Planning for the next phase begins after the requirements have been determined and involves the preparation of a risk-adjusted schedule for the remainder of the development cycle, the formulation of kickoff meeting agenda items, the identification and assignment of Domain Leads and Domain Subject Matter Experts (SMEs), the solicitation of participating stakeholders , and the arrangement of meeting logistics. The NAS Chief Architect presents the information at the Infrastructure Roadmap kickoff meeting, effectively communicating the purpose and objectives of the planned update, any new expectations or changes from the previous cycle, as well as the key activities and milestones to the applicable stakeholders (i.e., Domain Leads and SMEs).

**Updating Phase.** The Updating Phase begins immediately following the Infrastructure Roadmap kickoff meeting and follows the *NAS ISE Configuration Management Plan* processes outlined in Appendix D. Each Domain Lead updates their Roadmap by coordinating with their relevant roadmap working group consisting of participating stakeholders and assigned Domain SMEs. With Domain SME assistance, Domain Leads schedule and conduct working group meetings to identify changes to the assumptions, existing and planned systems, and their related decision points. The Roadmap team continues to update the roadmap and data iteratively and provides a Review Draft of their individual roadmaps to ANG-B2 per the defined schedule.

Once the individual Roadmap Review Drafts are complete, additional time is scheduled to focus on Roadmap integration sessions. Participants in these sessions include the NAS Chief Architect, Domain Leads, Domain SMEs, ANG-C and ANG-D representatives, and Air Traffic Organization (ATO) Program Management Office (PMO) representatives. The integration sessions seek to ensure relationships are accurately created and represented across each of the individual roadmap elements, as well as appropriately integrated with the architecture views and service roadmaps to create additional consistency and line of sight. At the completion of the integration sessions, ANG-B2 collects the individual roadmaps and data to cleanse and consolidate the roadmaps and data into a single package (i.e., Review Draft) that is prepared for review, comment and approval.

**Review and Approval Phase.** The Review and Approval phase is the last step in the annual maintenance process. The NAS Chief Architect provides successive briefs and baselined versions of the Roadmaps to the Technology Review Board (TRB) and the FAA Enterprise Architecture Board (FEAB) to obtain endorsement. Comments received during the review and briefings are assessed and adjudicated as necessary before the NAS Chief Architect briefs the JRC to obtain final approval. After JRC approval, a new baseline is established and the entire

process is repeated, starting with the Analysis and Planning phase for the next annual update cycle.

**Process Roles and Responsibilities.** Table 3 summarizes the active roles within the process and their general responsibilities.

**Table 3 Roles and Responsibilities for Infrastructure Roadmap Development**

| Role | Responsibility |
|---|---|
| Joint Resource Council | Provides final decision for Infrastructure Roadmap baseline |
| Technology Review Board | Provides technical endorsement of Infrastructure Roadmaps (delegated responsibility by the FAA Enterprise Architecture Board) |
| NAS Chief Architect | Provides overall orchestration of Infrastructure Roadmap development activity and status reporting |
| Domain Lead | Coordinates stakeholder collaboration and provides domain, system, and technical expertise for individual Infrastructure Roadmap development and integration (typically ATO Systems Engineering and Safety or Service-Unit personnel) |
| Stakeholder / ATO PMO | Provides system and technical expertise for individual Infrastructure Roadmap development and integration, and programmatic endorsement (typically ATO Program Office personnel) |
| Domain Subject Matter Expert | Provides development guidance and assistance to Lead Domain SME (typically contract personnel under direct NAS Chief Architect authority) |

**Decision Point Status Reporting.** Decision Point (DP) status reporting occurs in parallel with the annual Infrastructure Roadmap maintenance and continues throughout the year to inform architecture analysis and modeling efforts. Once a new Infrastructure Roadmap baseline is approved by the JRC, the progress made toward achieving the DPs for that year is continuously tracked by ANG-B2. As changes to DPs are inevitable throughout the year, an orderly, consistent method for analyzing, approving, and tracking changes is necessary. DP status is solicited monthly from Program Offices and is then reviewed and vetted by the NAS Chief Architect (ANG-B2) prior to being published on the NAS EA Portal. This process is further described in Appendix D, *NAS ISE Configuration Management Plan*. Table 4 details the different decision types and the criteria used to report Decision Point status.

**Table 4: Decision Point Status Criteria**

| | **AMS Decision Types**<br>• Concept and Requirements Definition Readiness Decision<br>• Investment Analysis Readiness Decision<br>• Initial Investment Decision<br>• Final Investment Decision<br>• Baseline Change Decision<br>• In-Service Decision | **Other Decision Types**<br>• FAA Policy<br>• FAA Strategy (JRC, other)<br>• Others |
|---|---|---|
| Green | • Satisfactory progress is being made towards reaching the target date as reported through the JRC Readiness Review Minutes | • Satisfactory progress is being made towards reaching the target date based on information provided by the Lead Organization |
| Yellow | • Progress is being made; however, the target date is at risk of being missed as reported through the JRC Readiness Review Minutes | • Progress is being made; however, target date is at risk of being missed based on information provided by the Lead Organization |
| Red | • Unsatisfactory progress is being made towards target date<br>• Target date has or is projected to be missed | • Unsatisfactory progress is being made towards target date<br>• Target date has or is projected to be missed |

The status of all Decision Points planned for the year, as well as those carried over from the previous year, if any, is reported regularly to the JRC Secretariat, Air Traffic Organization (ATO) Finance Investment Planning and Analysis Group, and other stakeholders during the following meetings to inform resource planning and requirements:

- Investment Decision Authority (IDA) Meetings. The JRC Executive Secretariat manages the executive level acquisition decision-making process for Investment Decision Authorities (IDA). The Secretariat holds weekly IDA Readiness Review meeting to guide program representatives through the activities for obtaining IDA investment decisions. The guidance includes identifying and completing the requirements of the FAA AMS. The program's acquisition DP's "planned date" is used to determine which programs are reviewed during the meeting. Meeting participation is dependent on the Acquisition Category of the program. Participants may include the NAS Chief Architect (ANG-B2), NAS Requirement Services Manager (ANG-B1), an ATO Finance representative, an ATO Program Management Office (PMO) representative, a Concept and Requirements Definition (CRD) representative, a NAS Lifecycle Integration Group (ANG-D) representative, and the FEAB Secretariat. led by the JRC Secretariat,
- EA Integration Meetings. The JRC Executive Secretariat leads a bi-weekly meeting to assess the progress and to obtain agreement on the status of each IDA Readiness checklist item for upcoming acquisition-related DPs. Meeting participants include the NAS Chief Architect, FAA Chief Architect, an ATO Finance representative, a CRD representative, a NAS Lifecycle Integration Group representative, and the FEAB Secretariat. If an agreement on DP status is not achieved, the ATO PMO is invited to the subsequent FEAB meeting to provide an informational briefing, at which point the FEAB grants final approval on the DP's status.
- Acquisition Quarterly Program Reviews (AQPR), also led by JRC Secretariat.

Status reporting includes the following data for each Decision Point:

- Location on roadmap
- Identification (Identifier, Name, Domain, Related Domains, Type, CY Target Date, Owner)
- Description
- Status detail, including state (Active, Completed, Deleted, or Replaced) and rationale for any changes
- Impacts, if any, expected to occur if decision is not achieved.

**High-Priority Decision Points.** Some of the DPs on the Infrastructure Roadmaps are identified as high-priority decisions. This is done to increase the attention and visibility of the program/project and the decision point to NextGen leadership and decision makers. The determination is made by the Infrastructure Roadmap lead in coordination with the Program/Project at the creation of the DP and is based on the following criteria. The DP:

- has projected/estimated benefits to the NAS, flying public, airlines, controllers, technicians, etc.
- is referenced on multiple other roadmaps (implies degree of dependence and size of impact if the DP slips)
- is associated with a large, complex NAS program/project
- is associated with a NAS program/project that has projected cost savings and reductions in FAA future budget (lifecycle cost savings)
- has complex entrance and exit criteria (i.e., # of stakeholders that need to be bought in, political sensitivity, who has to make the decision, etc.)

During the annual roadmap update process, the Infrastructure Roadmap leads review the high-priority DPs to ensure the speficied criteria is still applicable and make adjustments as necessary.

**Architecture Change Notices.** A DP date change in the Infrastructure Roadmaps for the current executing calendar year requires an Architecture Change Notice (ACN) to be completed two weeks prior to a JRC decision for the change to understand the rationale and architectural impact of the change. The ACN may be presented/discussed at either AQPR or the monthly JRC AMS decision boards. A template containing the information required for an ACN is provided by the JRC, with guidance provided by ANG-B2.

### *3.1.4 Funding Profile Maintenance*

The Funding Profile update is another activity that extends from the annual Infrastructure Roadmap development and update process. Each of the projects identified on a NAS Infrastructure Roadmap are explicitly associated with an FAA Capital Investment Plan (CIP) Budget Line Item (BLI) and the project durations on the roadmaps are consistent with the funding profile durations of the CIP. ANG-B2 compares the most recently published CIP (usually released in March of every year by the ATO Office of Strategic Planning) against the approved baseline version of the Infrastructure Roadmaps to determine if there are any differences or variations between the funding streams and the expected funding needed to satisfy

the implementation plans, as depicted in the roadmaps. Any identified variations are captured as Deltas. The Delta information is provided to the respective Infrastructure Roadmap Domain Lead to verify and validate, as well as inform Roadmap updates. The Roadmap team then develops an updated Forecast for funding based again upon their roadmap. Finally, the current CIP outlays, the Deltas, and the updated Forecasts are assembled in the format expressed in Section 2.2.2 of this document and are used as input into the FAA's annual budget request.

### *3.1.5 NAS Enterprise Architecture Development & Update*

The NAS EA development process follows a similar three phased approach as described in the Annual Infrastructure Roadmap Maintenance process. Proposed changes to baselined versions of the EA views are subjected to the *NAS ISE Configuration Management Plan* processes outlined in Appendix D.

**Analysis and Planning Phase.** This phase begins immediately following the establishment of an approved baseline or at the completion of a development phase, but prior to the review and approval phase. ANG-B2 architects perform analytical techniques (as described in Section 5) and review collected stakeholder feedback to determine new requirements for architecture content and view development. New requirements, including development schedules, required stakeholder involvement, and resource allocation are reviewed with the NAS Chief Architect for approval prior to initiating development. Scheduling focuses on the tasks described in following phases and includes periods for architecture review and comment, comment adjudication, architecture revision/development, and architecture approval. Resource allocation focuses on identifying and organizing resources, particularly architecture development personnel.

**Development Phase.** Once the development scope is approved, ANG-B2 architects coordinate and collaborate with the appropriate stakeholders to review existing data or collect new architecture data to be used for additional analysis and modeling. Coordination with other architects and stakeholders iteratively continues until the data is conditioned and interpreted accurately for incorporation into the architecture views (or data repository).

NAS EA development generally occurs in parallel to the data collection and analysis steps. Development may consist of architecture modeling following industry-accepted modeling techniques (e.g., IDEF0, BPMN, data flow, UML, etc.) and activities as designated for use in the most appropriate tool. The output of these collaborative development activities is an EA model that can be represented by multiple views and analytical reports ready for review and comment.

**Review and Approval Phase.** The Review Draft, which consists of revised and unrevised architecture views and a consolidated list of model changes, is published to the NAS EA Portal and released to a broader NAS EA team, as well as ANG-B1 and ANG-B3 for review and comment. Comments collected during this period are evaluated and resolved, including clarifying comments with their originators and documenting the disposition. Based on the comments and NAS Chief Architect direction, the ANG-B2 architects may revise the views or identify a need to build new views.

The NAS Chief Architect successively presents the Final Draft version of the architecture is to the TRB and the FEAB for review and comment. Comments submitted by either Board are

disposed and adjudicated. Once all comments are resolved and approved changes are implemented, the NAS Chief Architect briefs the JRC to obtain final approval. An approved baseline is established and published to the NAS EA Portal, the content of which serves as the definitive context for vertical integration with Program-level architectures.

**Process Roles and Responsibilities.** Table 5 summarizes the active roles in the process and their general responsibilities.

**Table 5: Roles and Responsibilities for Enterprise-level Architecture Development**

| Role | Responsibility |
|---|---|
| Joint Resources Council | Acts as authority for the establishment of NAS EA baselines |
| FAA Enterprise Architecture Board | Provides endorsement of Enterprise-Level architectures |
| Technology Review Board | Provides technical review and endorsement of Enterprise-Level architectures |
| NAS Chief Architect | Provides overall orchestration of Enterprise-Level architecture development |
| Architecture Developers | Provides technical expertise for the development and revision of Enterprise-Level architecture views |
| Stakeholder | Provides technical review and comment of Enterprise-Level architecture views |

## 3.2 NAS Requirement Development and Maintenance

Enterprise-level requirement development largely follows the process prescribed by the FAA's System Engineering Manual (SEM) Section 4.3 – Requirement Management.

**Planning Phase.** The planning process begins after the most recent versions of the documents are approved and baselined by the JRC. This process consists of reviewing stakeholder feedback to determine the necessary enhancements to the NAS-RD series in order to fully describe the requirements and its scope, as well as to make it easier to derive Program-level requirements. Resources are allocated based on the nature of the enhancement and the timeframe addressed by the updates.

Segment Integration requirements are also generated during this phase. They represent the requirments of the OI Increments, and are allocated to Portfolios and Programs. These requirements are mapped into the appropriate segment of the NAS-RD series, and contain schedule data based on the expected decision points of the programs to which they are allocated.

**Updating and Development Phase.** This phase starts when enhanced versions of the NAS-RD series of documents are released. The updated documents are made available to stakeholders for review and comment for a given period of time. Once the comment phase is complete, the Requirements Integration Manager (ANG-B1) will review the feedback, coordinate with the appropriate stakeholders, and adjust the documents as necessary. Dispositions on the status of the comments will be provided by the Requirements Integration Manager to the stakeholders.

Since the initial baseline, the NAS-RD series of documents is updated annually to ensure that it stays aligned with the current and future NAS. Updates to the current requirements baseline

document are be submitted via NAS Change Proposals (NCP) submitted to the NAS Configuration Control Board (NAS CCB).

Updates to the requirement documents for future timeframes start with a review and comment period open to FAA stakeholders. Once the comment period ends, the requirement engineers examine and resolve comments, including clarifying comments with their originators and documenting disposition. This process is further described in the *NAS ISE Configuration Management Plan* processes outlined in Appendix D.

**Approving Phase.** Changes to existing As-Is requirements are approved when the NAS CCB accepts the submitted NCP. The requirements for future timeframes are approved by the TRB, followed by the FEAB. Additional comments from either Board may be submitted for disposition and adjudication. Once the comments are resolved, the JRC establishes the updated NAS-RD documents as the Enterprise-level requirements baseline for the NAS.

**Process Roles and Responsibilities.** Table 6 summarizes the roles and responsibilities that are involved in the Enterprise-level Requirements development process.

**Table 6 Roles and Responsibilities for Enterprise-level Requirements Development**

| Role | Responsibility |
|---|---|
| Joint Resources Council | Provides the highest level approval decision for a baseline NAS-RD |
| FAA Enterprise Architecture Board | Provides endorsement of NAS-RD |
| Technical Review Board | Provides review and compliance assessment for the NAS-RD |
| NAS Systems Engineering Services Director | Provides Systems Engineering approval and assessment for the NAS-RD |
| Requirements Integration Manager | Coordinates the enterprise level development, approval recommendation, and updating cycle of the NAS-RD |
| Domain Lead | Provides subject matter domain expertise to the various NAS-RD domain areas |
| Stakeholder | Provides technical review and comments to the NAS-RD |

## 3.3 Safety Hazard Identification and Management

Safety assessments (e.g., program level, ISSA) produce safety information that can then be connected to NAS EA elements. This information is updated as new safety assessments are completed. Hazard Traceability Views (HTVs) provide a safety perspective into the NAS EA by depicting that same information and their traceability between hazards, EA elements, and requirements. These HTVs, dynamically developed on an as needed basis, are used by stakeholders to aid their safety analysis efforts.

## 3.4 Enterprise-level Systems Engieering Product Alignment/Integration

During the updating and development phases of the requirements, architecture, and safety hazard development processes, steps are taken by the NAS Chief Architect (ANG-B2), the Requirements Integration Manager (ANG-B1), and NextGen Safety and Security Manager (ANG-B3) to ensure the enterprise-level requirement statements, appropriate architecture views, and the latest safety information remain aligned. This involves input and review from ANG-B1, ANG-B2, and ANG-B3 personnel and Subject Matter Experts (SME) to establish or update

linkages between future requirements, anticipated system functions from the SV-4, and identified safety hazards. The identified linkages are ultimately captured within the approved and licensed systems engineering tools (e.g., IBM Rational System Architect and DOORS), and posted to the NAS EA Portal per publication business rules. Additional steps outlined in Appendix D, *NAS ISE Configuration Management Plan* are taken when a proposed change is made to an architecture element, NAS requirement, or safety data that has an established relationship, and vice versa.

# 4 PROGRAM-LEVEL PROCESSES AND PRACTICES

## 4.1 Architecture and Requirements Products by Acquisition Phase

Program-level requirements and architecture development primarily occur during the earliest phases of the FAA's AMS lifecycle, specifically: Concept and Requirements Definition (CRD), Initial Investment Analysis (IIA), and Final Investment Analysis (FIA). Program system, safety, and security engineers, requirement analysts, and architecture developers must produce a minimum set of documentation during each phase to support the next decision in the lifecycle (subject to tailoring based on investment scope and acquisition category). These requirements are outlined in the JRC Investment Decision Authority (IDA) Readiness Checklist and are described below and in Figure 8.

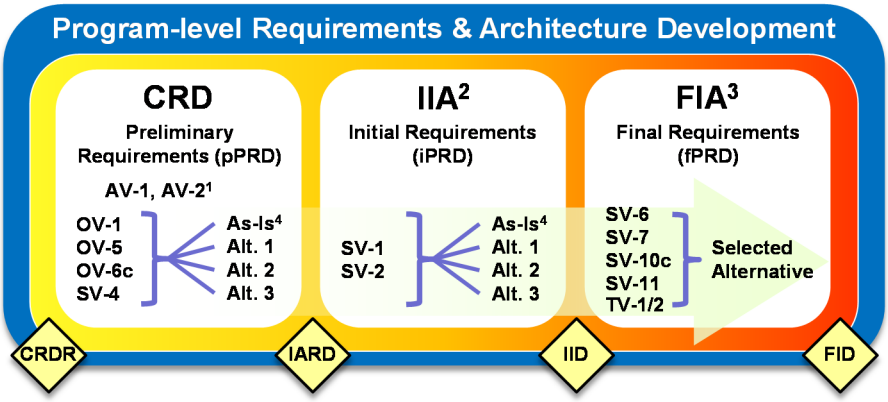



**Figure 8: Required Architecture and Requirement Products per Acquisition Phase**

**Special Considerations.** The DoDAF contains additional products which may be prescribed for program-level development in addition to or as replacements for the products listed above. The decision to add, remove, or replace architecture products is made jointly between the NAS Chief Architect and the Program Manager or designee. In addition, program-level architectures representing "legacy" system efforts (e.g., Baseline Change, SLEP, Technical Refresh, etc.) are generally limited to AV-1, AV-2, SV-1, SV-2, and SV-4 for As-Is only.

### *4.1.1 CRD Phase (For As-Is and Each Alternative)*

Per the AMS, Program-level requirements and architecture development begin with Concept and Requirements Definition Readiness Decision (CRDR) and the CRD phase. In this phase, a Functional Analysis, Operational Safety Assessment (OSA), and Security Risk Assessment (SRA) is performed to inform the development of a preliminary Program Requirements Document (pPRD), a range of alternatives is identified, and concept(s) of operation is developed.

Each solution within the range of alternatives, including the current, or "As Is," is represented, at minimum, by the following views:

- Overview and Summary Information (AV-1)[2]
- Integrated Dictionary (AV-2)[3]
- High-level Operational Concept Graphic (OV-1)
- Operational Activity Hierarchy Model (OV-5)
- Operational Event-Trace Description (OV-6c)
- System/Service Functional Hierarchy Model (SV-4)

The OV-1 summarizes the concept(s) of operation/use, and the OV-5, OV-6c, and SV-4 play critical roles in organizing and understanding preliminary requirements. All architecture elements (e.g., Operational Activities, System Functions, Data Elements, etc.) used in these products are defined, and relationships between them identified, in the AV-2. The AV-1 summarizes the entire architecture effort.

### *4.1.2 IIA Phase (For As-Is and Each Alternative)*

The Investment Analysis Readiness Decision (IARD) ends the CRD phase and initiates the IIA phase in which the pPRD is refined to create an initial requirement documents (iPRD), Security Risk (SRA) and Comparative Safety Assessments (CSA) are conducted, comprehensive alternative analyses are performed, and lifecycle cost estimates are produced. For each alternative, the following additional views are developed and integrated with the views developed during CRD:

- Continued maturation of CRD Phase architecture products, as necessary
- System/Service Interface Description (SV-1)
- System/Service Communications Description (SV-2)

Architecture elements modeled in SV-1 and SV-2 are defined in the AV-2 and additional element-to-element relationships are captured. With system components and allocations to functions understood architecturally, additional requirements can be defined. Comparing solution architectures contributes directly to comprehensive alternative analyses and trade studies. Further, cost figures applied against various architecture elements form the foundation for lifecycle cost estimating. Finally, the AV-1 is updated in preparation for the Initial Investment Decision (IID).

### *4.1.3 FIA Phase (For As-Is and Selected Alternative)*

Providing a down-select from alternative solutions to one preferred solution, IID ends the IIA phase and initiates the Final Investment Analysis (FIA) phase where Security Risk Assessments are refined, Preliminary Hazard Analyses (PHA) are performed, and the investment analysis team develops the final program requirements (fPRD). The following complementary architecture views are developed during FIA:

[2] The AV-1 is relevant to all the products for all alternative solutions.

[3] The AV-2 may be segmented by alternative solutions.

- Continued maturation of CRD and IIA Phase architecture products, as necessary
- System/Service Data Exchange Matrix (SV-6)
- System/Service Performance Parameters Matrix (SV-7)
- System/Service Event-Trace Description (SV-10c)
- Physical Schema (SV-11)
- Technical Standards Profile/Forecast (TV-1/2)

Development of SV-6, SV-7, SV-10c, SV-11, and TV-1/2 provides data exchange, system interface, functional sequencing, physical data structures, and technical considerations that contribute to final requirements definition in preparation for Solution Implementation. Definitions of SV-11 data elements and their relationships to other architecture elements are populated in the AV-2. Finally, the AV-1 is updated to reflect the efforts undertaken during FIA in preparation for Final Investment Decision (FID) and entry into the Solution Implementation phase.

## 4.2 Program-Level Architecture Development Process

This section focuses on Program-level architecture development (may also be represented by an individual Project) supporting the FAA AMS decision-making process, from initial concept development to the start of solution implementation. ANG-B2 Architects primarily serve in an advisory role to the Program going through the AMS; however, the NAS Chief Architect may decide to engage ANG-B2 Architects in the actual architecture development depending on the size of the program and the availability of program resources to develop the required architecture products.

### *4.2.1 Architecture Development*

The process for Program-level architecture development follows a similar three phased approach as the Enterprise-level architecture development and maintenance process, and reflects the activities and decisions related to the development of architecture views, as well as the horizontal and vertical integration of the views (including alignment with Program-level Requirement Documents), and their review and approval. Figure 9 illustrates the process with a notional timeline that starts and ends with an AMS decision.

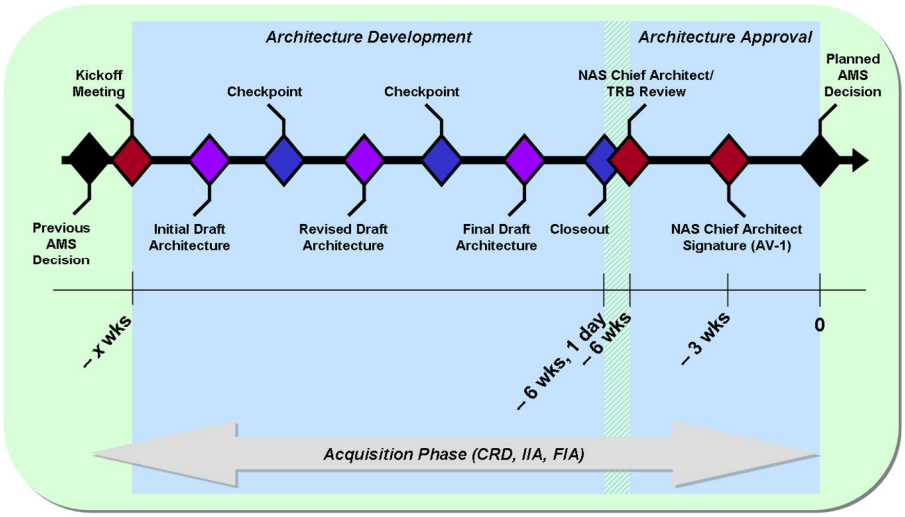



**Figure 9: Program-level Architecture Development and JRC Decision – Notional Timeline**

**Analysis and Planning Phase.** This stage begins immediately following a CRDR Decision, an IARD, or an IID and is executed within the subsequent CRD, IIA, and FIA phases, respectively. ANG-B2 Architects coordinate an architecture development kickoff meeting with the NAS Chief Architect and Program-level Architect. Prior to the kickoff, ANG-B2 Architects prepare a recommended architecture product set for development and a proposed high-level development schedule. The proposed schedule is developed from the planned AMS decision date, working backwards to the kickoff meeting. The typical product set recommendation includes the architecture products in Figure 8 above per AMS phase. However, the NAS Chief Architect may approve tailoring of the product set. Through tailoring, products from the prescribed list may be removed, and other relevant products added depending on a particular program's needs and constraints.

At the kick off meeting, ANG-B2 Architects, the NAS Chief Architect, and Program-level Architect review the recommended product set and proposed schedule. They raise and deliberate issues not resolved during kickoff coordination as well as discuss any needs or constraints not previously coordinated. Finally, the NAS Chief Architect and Program-level Architect agree on the schedule and product set, effectively initiating architecture development.

**Development Phase.** Architecture development occurs immediately following the kick off meeting and continues up to 6 weeks prior to the planned AMS decision. Within this timeframe, a set of delivery and checkpoint milestones is identified for architecture development. A development milestone, shown as a purple diamond in Figure 9, indicates when the architecture is ready for ANG-B2 Architect review and comment (including quality assurance/control), per the agreed upon development and checkpoint milestones. In most cases, there should be at least three development milestones per AMS phase; an initial draft; at least one revised draft; and final draft architecture. A checkpoint milestone (blue diamond) gives the Program-level Architect the opportunity to consult with ANG-B2 Architects and the NAS Chief Architect about product status and discuss issues and actions regarding architecture development and integration. Also, the checkpoints indicate to the Program-level Architect when the review results may be expected from the Enterprise Architect against the developed products.

ANG-B2 Architects review the Program-level architecture products against a set of development

and integration criteria and submit review comments in the form of a Comment/Resolution table to the Program-level Architect for resolution. The ANG-B2 Architects may also collect change recommendations from the Program-level Architect against the Enterprise-level architecture to be vetted during its updating cycle, as described in Section 3.1 above. After multiple iterations of product development, review, and comment, the Program-level Architect provides a Final Draft of the architecture to ANG-B2. The Final Draft includes all agreed-upon architecture products (including the architecture impact assessment as part of the AV-1) for the Final Draft milestone unless otherwise waived by the NAS Chief Architect. At this point, ANG-B2 Architects prepare for Closeout.

The Closeout milestone is a special checkpoint because it effectively ends architecture development for the phase and initiates the Architecture Approval stage. The ANG-B2 Architects prepare for Closeout by finalizing a descriptive state of the architecture. This includes the comments concerning the Final Draft architecture and impact assessment, highlighting the proposed resolutions, as negotiated with the Program-level Architect, regarding all remaining open comments. Closeout becomes formal once the ANG-B2 Architects deliver the architecture to the NAS Chief Architect for review and approval.

**Review and Approval Phase.** This phase begins immediately after the Closeout checkpoint with Program-level Architect delivery and presentation of the entire architecture package to the NAS Chief Architect and the Technology Review Board (TRB) to ensure the architecture accurately reflects the current and desired technical content for standards, systems, and infrastructure. Ideally, the review occurs over a 3-week period. The TRB provides its recommendations and observations to the Program-level Architect and NAS Chief Architect for resolution. The NAS Chief Architect signs the AV-1 no later than 3 weeks before AMS decision. The AV-1 becomes the official document representing the entire architecture for the phase, indicating to the Joint Resources Council that all AMS requirements relevant to Program-level enterprise architecture development have been met. Once the Program receives its AMS decision to proceed, ANG-B2 baselines the Program-level architecture and publishes the architecture package either to the NAS EA Portal (for FID only) or Program Architecture Locker (for IARD and IID).

**Process Roles and Responsibilities.** Table 7 summarizes the active roles in the process and their general responsibilities.

**Table 7: Roles and Responsibilities for Program-level Architecture Development**

| Role | Responsibility |
|---|---|
| Program-Level Architect | Coordinates and develops program-level architecture development (En Route and Oceanic Services; Terminal Services; System Operations Services; Technical Operations Services) |
| NAS Chief Architect | Approval authority for all NAS Program-Level architectures (NextGen and Operations Planning Services) |
| ANG-B Architects | Provides development guidance and assistance to Program Office Program-Level architecture efforts (Typically contract personnel under direct NAS Chief Architect authority) |
| Technical Review Board | Provides review and compliance assessment of all NAS Program-Level architectures (delegated responsibility by the ATO Enterprise Architecture Board) |

## 4.3 Program-Level Functional Analysis Development

This section focuses on Program-level functional analysis development in support of the FAA's AMS decision-making process. The Functional Analysis Document (FAD) contains the results of the functional analysis process which decomposes an operational concept into preliminary top-level functions and data needs.

### *4.3.1 Functional Analysis Development Process*

Program-level functional analyses are structured and organized in the format described by the Functional Analysis Document Template, which is one of the Acquisition Planning and Control Documents within the AMS. Appendix A provides details on the contents of the FAD.

**Development Phase**. The sponsoring program office initiates FA with the support of the NAS Requirements Services Division (ANG-B1) during the Concept and Requirements Development (CRD) phase of the AMS lifecycle. Although the bulk of the FA is conducted during the CRD phase, the FAD must be continually updated as a program matures their acquisition through the IIA and FIA phases. Prior to the development of the final program requirements (fPR), each program re-examines the FAD and updates it if necessary. This is done iteratively as a program progresses through the initial investment analysis (IIA) and the final investment analysis (FIA) phases in order to validate the required functions and data needs based on new requirements that may have been added. The fPR is directly traceable to the most recent FAD and defines the intended functional and performance requirements which the investment program intendeds to achieve. The FAD also needs to be traceable to the functions listed in the program's EA SV-4. The FAD serves as a useful tool for evaluating the readiness of resultant products and services to be fielded for operational use within the FAA. After a successful FID, the program baselines their FAD, and this base-lined FAD will be the version used as the starting point when a program seeks to update their capabilities as part of a new investment cycle.

**Approval Phase**. The functional analysis approval phase begins upon delivery of the FAD to the NAS Requirements Services Division (ANG-B1). Typically, this occurs several months prior to the IARD AMS decision point. ANG-B1 is usually intimately involved with the program in developing the FAD, and it is not expected of a program to conduct their functional analysis in isolation. A review process is conducted internally within ANG-B1 in coordination with ANGF-B2 to ensure that the FAD has successfully met all the SEM, AMS, and ANG-B1 evaluation criteria, including alignment to the program requirements document, traceability to the solution ConOps, and alignment to the program's EA SV-4 artifact. An ongoing part of this process includes coordination with the program office throughout the AMS phases to keep current with changes to the FAD as well as resolving any outstanding issues. Once a FAD is determined to have satisfied all ANG-B1evaluation criteria, it is formally approved by the NAS Engineering Services Director (ANG-B), indicating to the Joint Resources Council, that all AMS requirements relevant to Program-level functional analysis development have been successfully met.

**Process Roles and Responsibilities.** Table 8 summarizes the roles and responsibilities that are involved in the Program-level requirement development process.

**Table 8 Roles and Responsibilities for Program-level Requirements Development**

| Role | Responsibility |
|---|---|
| NAS Engineering Services Director | Provides Systems Engineering approval and assessment for the FAD |
| Functional Analysis Integration Manager | Provides program level development guidance along with coordinating the review and approval of the FAD |
| Domain Lead | Provides subject matter domain expertise and serves as the primary reviewer of the FAD |
| Program-level Functional Analyst | The primary developer of the FAD for the program office |

## 4.4 Program-Level Requirement Development

This section focuses on Program-level requirement development in support of the FAA's AMS decision-making process. The Program Requirement Document (PRD) establishes the operational framework and performance baseline for an investment program. It is the basis for evaluating the readiness of products and services of an investment program to become operational. ANG-B1 requirement engineers primarily serve in an advisory role to the Program going through the AMS.

It is important to note that the Safety and Information Security Services Division (ANG-B3) also provides safety management and information security support to program offices, which results in safety and security requirements in the Program Requirement Document. ANG-B3 is also a must reviewers for all safety and information security products supporting the AMS milestone decisions. This process is further documented in the Safety Risk Management Guidance for System Acquisitions v1.5 (SRMGSA).

### *4.4.1 Requirements Development Process*

Program-level requirements are structured and organized in the format described by the Program Requirements Template, which is one of the Acquisition Planning and Control Documents within the AMS developed by ANG-B1. The program requirement document is written to be solution agnostic, and therefore should be implementable as developmental, non-developmental, or commercial acquisitions. Appendix A provides a reference to the Program Requirements template.

**Development Phase.** The sponsoring program develops a pPRD during the CRD phase, which translates the operational or functional need identified through EA analysis into preliminary top-level functional and performance requirements (inclusive of safety and information security requirements). During initial investment analysis, a more detailed iPRD is developed from the pPRD, as preliminary requirements are evaluated against the cost, benefits, schedule, and risk of various alternatives and brought into balance with an affordable solution to mission need.

The investment analysis team, which includes the program office, develops an fPRD during final investment analysis, which undergoes a formal review and approval process from the JRC. This document defines the concept of use and performance requirements which the investment program intends to achieve and forms the basis for evaluating the readiness of resultant products and services to be fielded for operational use within the FAA. Any requirements not in the fPRD are returned to the sponsoring program office for disposition.

If a particular program imposes a requirement upon another program in their pPRD or fPRD, that requirement will be managed via a Service Level Agreement (SLA) between the two program offices. Through the SLA, the program office imposing the requirement and will include the requirement in their documentation, while the program office receiving the requirement will have a process in place for managing the assigned requirement. Appendix A provides a template for developing this SLA.

After a successful FID, the program develops a System Specification derived from the fPRD, and is included with a Request for Offers to prospective contractors who wish to bid on the procurement of the investment program.

**Approval Phase.** The requirements approval phase begins upon delivery of the applicable requirement products (Functional Analysis, pPRD, iPRD, fPRD) to the NAS Requirements Services Division (ANG-B1). Typically, this occurs several months prior to the scheduled AMS decision point. A review process is conducted internally within ANG-B1 and ANG-B3 to ensure that the Program Requirement Document has successfully met all the SEM, AMS, ANG-B1 and ANG-B3 evaluation criteria, including alignment to the NAS-RD series, integration with NAS-RD series and other program requirements, and conformance to AMS requirement guidelines. An ongoing part of this process includes coordinating with the program office throughout the AMS phases to keep current with changes to the requirement documents as well as resolving any outstanding issues. Once a Program Requirement Document is determined to have satisfied all ANG-B1 evaluation criteria, it is formally approved by the NAS Engineering Services Director (ANG-B), indicating to the Joint Resources Council, that all AMS requirements relevant to Program-level requirement development have been successfully met.

**Process Roles and Responsibilities.** Table 9 summarizes the roles and responsibilities that are involved in the Program-level requirement development process.

**Table 9 Roles and Responsibilities for Program-level Requirements Development**

| Role | Responsibility |
|---|---|
| NAS Systems Engineering Services Director | Provides Systems Engineering approval and assessment for the PRD |
| Requirements Integration Manager | Provides program level development guidance along with coordinating the review and approval of the PRD |
| Safety and Information Security Manager | Provides SMS and information security support, and are must reviewers for all safety and information security products supporting the AMS milestone decisions. |
| Domain Lead | Provides subject matter domain expertise and serves as the primary reviewer of the PRD |
| Program-level Requirements Engineer | The primary developer of the PRD for the program office |

## 4.5 Program-level Architecture and Requirements Alignment/Integration

While the disciplines are performed separately, Program-level FA and requirements inherently drive the corresponding Program-level architecture models; creating a symbiotic relationship and a requirement for the system engineering documentation to be consistent. To emphasize the integration and consistency of Program-level FA, requirement documents, and architecture products, additional coordination and collaboration activities are inserted throughout the

processes described in Sections 4.2 and 4.3 above, and include:

- **Joint Kick Off Meetings** – This meeting is intended to provide a general overview of the NAS ISEF to include aspects of EA, FA, requirements, and safety and information security consideration s within the requirements; provide scoping decisions related to the program's decision points; and, provide development guidance and schedules, including instructions for accessing available tools. Meeting participants include the Program office representatives, NAS Requirements Services Manager (ANG-B1), NAS Chief Architect (ANG-B2), NAS Safety and Information Security Services Manager (ANG-B3), and support personnel.
- **Integration Checkpoint Meetings** – This meeting is intended to gain insight on development and integration progress; provide a forum for questions/answers; gather data for larger enterprise initiatives; and provide comments and feedback to avoid large scale fixes towards the end of the effort. Meeting participants include the Program-level Safety, Security, and Requirements Engineer(s), Program-level Architect(s), and representation from ANG-B (B1, B2, and B3).
- **Product Integration Review and Analysis** – This activity is performed by ANG-B (B1, B2, and B3) personnel in parallel to quality assurance/control reviews to assess the level of horizontal and vertical integration of Program-level architecture products and requirement documents. The result of this activity is captured in a comment sheet that is used to inform the Technical Interchange Meeting.
- **Technical Interchange Meeting** – This meeting is intended to provide ANG-B1, ANG-B2, ANG-B3, and the Program Manager and representatives an opportunity to discuss horizontal and vertical integration findings and recommendations; provide QA/QC comments for the developed draft sets of products; and provide recommendations for enhancements to finalize each sets of products.
- **Joint Closeout Meeting** – This meeting is intended to provide ANG-B1, ANG-B2, and ANG-B3 an opportunity to make any final comments or recommendations against the final phase products. This meeting is also intended to gain approval for Program-level products (including signatures) and provide favorable notification to the JRC Secretariat (adhering to the JRC close out process). An end-of-phase questionnaire will also be offered to collect feedback on ANG-B's services throughout the entire process.

These activities augment existing development review and coordination processes described in Sections 4.2 and 4.3, as well as supplement them by providing a joint ANG-B perspective early and often throughout the development process. The intended purpose is to make sure the Program-level requirement engineers and architects are collaborating with each other, the PRD and architecture products are aligned either manually or within available approved and licensed architecture and requirement development tools (e.g., IBM Rational System Architect and DOORS), and horizontal and vertical integration is also occurring. Details regarding the mechanics of the activities are presented at the Joint Kick Off meetings with the Program office representatives.

# 5 INTEGRATED SYSTEMS ENGINEERING ANALYSIS

With the ISEF, the FAA has an effective framework to organize and relate the significant collection of information describing the NAS. The information can be condensed, analyzed,

interpreted, and web-enabled via the NAS EA Portal to inform governance-based decision making and communications across the stakeholder community and enhance the use of resources to fulfill the NAS mission. The information can also support traditional planning disciplines including strategic planning, portfolio and project management, capital planning and investment control, cost/benefit/risk modeling, etc. throughout the FAA AMS lifecycle.

As the scope, fidelity, and accuracy of integrated systems engineering related information matures, so does ANG-B's ability to implement an analytical framework to respond to questions like:

- What are the performance-driven capability needs, opportunities, and solution alternatives that the FAA should invest in?
- Should the FAA invest/continue to invest in a particular capability/program/system, etc?
- What happens if a program/project's schedule, funding, or scope is changed?

The integrated systems engineering information can be organized/represented by any element described in the ISEF Metamodel to support various analytical techniques and applications. Examples of analytical techniques used to help respond to these types of questions include, but are not limited to the following:

- ***Strategic Alignment Analysis*** to understand the extent by which elements directly align to NAS and NextGen mission goals and objectives
- ***Value Delivery Analysis*** to understand how an element enables/contributes to the achievement of an Operational Improvement (and underlying benefit) with respect to NAS service delivery
- ***Dependency/Interdependency Impact Analysis*** to identify and understand elements that may be impacted as a result of funding cuts, schedule slippages, reduced scope, etc.
- ***Gap Analysis*** to identify functional gaps and verify to-be architecture and requirements to ensure they address the mission need and shortfalls recognized from its corresponding As-Is architecture and requirements
- ***Interoperability/Integration Analysis*** to identify elements with the same or similar names, definitions, etc. in order to assess opportunities for collaboration/convergence, consistency and reuse
- ***Multi-attribute Solution Analysis*** can be applied against the data attributes to evaluate solution alternatives identified at the Enterprise- and Program-levels (e.g., trade-offs) and adds an additional level of fidelity to enable the FAA to analyze capability performance and the NAS trade space against strategic performance objectives

These capability-based analysis techniques apply to multiple layers and perspectives of the NAS (i.e., enterprise, portfolio, functional segment, program/project, system, etc.) during and after architecture and requirement development. They are intended to help understand what whould happen if a change occurs, before the change takes place. This form of impact assessment is seen in the Program-level AV-1, described in Appendix A, and is used to support discussions in the TRB and JRC meetings.